{In Archive} West Lake Landfill: Fw: REDLINE of revised Section 3 - RIM Characterization

Dan Gravatt to: Audrey Asher, Cecilia Tapia, Matthew Jefferson, Charles Openchowski, Doug Ammon, Elizabeth Southerland — 05/20/2011 02:26 PM

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FYI, based on the action items from our meeting in KC on May 18, this is the first of the PRPs' promised redlines of the proposed EPA text.

Sincerely,
Daniel R. Gravatt, PG
US EPA Region 7 SUPR / MOKS
901 North 5th Street, Kansas City, KS 66101
Phone (913) 551-7324 Fax (913) 551-7063

----- Forwarded by Dan Gravatt/R7/USEPA/US on 05/20/2011 02:22 PM -----

From:	"Paul Rosasco" <paulrosasco@emsidenver.com>
To:	Dan Gravatt/R7/USEPA/US@EPA, "'Muenks, Shawn'" <shawn.muenks@dnr.mo.gov>, Rich Kapuscinski/DC/USEPA/US@EPA
Cc:	"'Merrigan, Jessie'" <JMerrigan@LathropGage.com>, "'Kate Whitby'" <kwhitby@spencerfane.com>, <VWarren@republicservices.com>, <charlotte.neitzel@hro.com>, "'Bob Jelinek'" <bobjelinek@emsidenver.com>
Date:	05/20/2011 01:38 PM
Subject:	REDLINE of revised Section 3 - RIM Characterization

Attached please find a redline version of our prior submittal of the new Section 3 – RIM Characterization. This version incorporates changes consistent with our discussions at our meeting earlier this week.

Please note that we still intend to include the discussion of the volume of RIM as part of the description of the various alternatives so that it occurs after the discussions of the potential ARARs and cleanup levels. Also portions of Section 3 were retained in the revised redline as they address other comments (e.g., MDNR comment 19) that we received on the draft SFS.

Section 3 - RIM Characterization Redline 5-20-11.doc

3 RADIOLOGICALLY-IMPACTED MATERIALS

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This section summarizes the origin and general nature and distribution of the radiologically-impacted materials (RIM) occurrences in Areas 1 and 2. The characterization of the RIM occurrences is based on the results of the prior Nuclear Regulatory Commission (NRC) investigations of the site (NRC, 1982 and 1988 and RMC, 1981), and the results of the sampling performed during the RI (McLaren/Hart 1996, EMSI, 1997 and 2000).

3.1 Source of the RIM

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Reportedly, 8,700 tons of leached barium-sulfate residues were mixed with approximately 39,000 tons of soil and then transported to the West Lake Landfill in 1973 (EPA, 2008, NRC, 1988). The barium-sulfate residues were reportedly derived from Uranium ore processing and were initially stored by the Atomic Energy Commission (AEC) on a 21.7-acre tract of land in a then-undeveloped area of north St. Louis County, now known as the St. Louis Airport Site (SLAPS) (EPA, 2008, NRC, 1988 and 1982). SLAPS is part of the St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) sites which are managed by the U.S. Army Corps of Engineers (USACE). Certain Radium and lead-bearing residues, known as K-65 residues, were stored in drums at SLAPS prior to relocation to federal facilities in New York and Ohio (EPA, 2008, NRC, 1988). In 1966 and 1967, certain remaining residues from SLAPS were purchased by a private company for mineral recovery and placed in storage at a nearby facility on Latty Avenue under an AEC license (EPA, 2008, NRC, 1988). Most of the residues were shipped to Canon City, Colorado, for reprocessing (EPA, 2008, NRC, 1988). Leached barium-sulfate residues were not shipped off-site as these were the least valuable in terms of mineral content because most of the Uranium and Radium had been removed in previous precipitation steps (EPA, 2008, NRC, 1988).

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3.2 General Locations of RIM Occurrences

Radionuclides have been identified as being present in two distinct and separate areas at the landfill. These two areas have been designated as Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2) (Figure 12). Prior investigations of radionuclide occurrences at West Lake Landfill (RMC/NRC, 1982, NRC, 1988, EMSI, 2000, EMSI, 2006, and EMSI, 2010) have identified these same two areas as the locations where radionuclides are present at the Site. Area 1 encompasses an approximately 10 acre portion of the site located immediately to the southeast of the main entrance road to the West Lake Landfill property. Area 2 encompasses approximately 30 acre portion of the site along the northern boundary of the West Lake Landfill property (Figure 12).

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NRC (1988) described the extent of radiological occurrences in Area 1 and 2 as being 3 acres and 13 acres in size respectively. The RI report (EMSI, 2000), identified somewhat larger extents of radiological occurrences including 4.5 acres in Area 1 and 19.2 acres in Area 2. The results of both the NRC investigations and the RI indicated that the subsurface extent of radionuclide occurrences in Areas 1 and 2 is greater than the surface extent of radionuclide occurrences in these areas.

The RI also identified approximately 4.5 acres of the adjacent (northern) property (formerly the Ford property but subsequently known as the Buffer Zone and a portion of the Crossroad property) as potentially containing radiological occurrences in surficial soil. It should be noted that subsequent to the RI, this area was scraped and graded by the occupant of the adjacent property, with much of the surficial soil being pushed back toward the landfill. In addition, gravel cover was placed over the Crossroad portion of this area. Consequently, the current extent of radiological occurrences in this area is uncertain and therefore will be subject to additional characterization during the Remedial Design effort.

During preparation of SFS, the extent of radiological occurrences in Areas 1 and 2 was rigorously examined to provide a basis for estimating the volume of material that would need to be excavated pursuant to the "complete rad removal" alternatives. The data collected during both the NRC and the RI investigations were used in this evaluation. The specific procedures and data used to identify the extent of radiologically-impacted materials are fully described and presented in Appendix A to the SFS. Based on the SFS evaluations, the extent of radiological occurrences in Areas 1 and 2 were defined to be 4.4 acres and 21.7 acres, respectively. The areal extent of the RIM occurrence identified during the SFS for Area 1 (4.4 acres) is similar to the areal extent (4.5 acres) previously identified during the RI, but greater than the 3 acre extent identified by NRC (1988 and 1982). The areal extent of the RIM occurrence identified during the SFS for Area 2 (21.7 acres) is 13% greater than the areal extent (19.2 acres) previously identified during the RI, and substantially larger than the 13 acre extent identified by NRC (1988 and 9182). The greater extent of RIM estimated during the SFS results from use of more rigorous procedures to define the extent of RIM during the SFS, and development of separate estimates of the lateral extent of upper and lower subsurface occurrences of RIM in Area 2.

Figure 1 presents and compares the extent of RIM identified in the 1982 NRC report, the 1988 NRC report, the 2000 RI report, and the 2010 SFS report. All four reports identified similar general areas of RIM occurrences at the site.

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3.3 General Distribution of RIM Occurrences

Radionuclides are present in a dispersed manner throughout the landfill deposits in Area 1 and Area 2. Radiological constituents primarily occur in soil that was reportedly used as daily or intermediate cover. According to the landfill operator, the soil was used as cover for municipal refuse in routine landfill operations (TetraTech, 2009). Data collected during the RI are consistent with this account (TetraTech, 2009). Based on the presence of RIM with thickness greater than a few feet in certain locations, direct disposal of soil mixed with barium-sulfate residue may also have occurred at Areas 1 and 2; however, the RI soil boring logs did not identify the presence of any intervals consisting exclusively or predominantly of soil. Therefore, any soil containing barium-sulfate residue that may have initially been directly disposed at the landfill appears to have become mixed with waste materials as a result of concurrent or subsequent landfilling activities or differential settlement of the landfill materials over time.

The RI found that "…the radiologically impacted materials present in Areas 1 and 2 are distributed throughout an overall matrix of solid waste materials including sanitary (household) wastes and construction and demolition debris." The RI goes on to state "Based upon observations of the cutting materials brought to the ground surface during the boring program, extensive discrete layers of soil, whether impacted or otherwise, were not identified." The RI also states "… a large portion of the radiologically impacted materials are present in the subsurface and occur in an interlayered and interspersed manner among the solid waste materials." The RI states further that "…occurrences of elevated downhole gamma readings as well as occurrence of radionuclides above reference levels or, even above background, were associated with a wide variety of solid waste materials containing varying amounts of soil."

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3.3.1 Type of Information Obtained

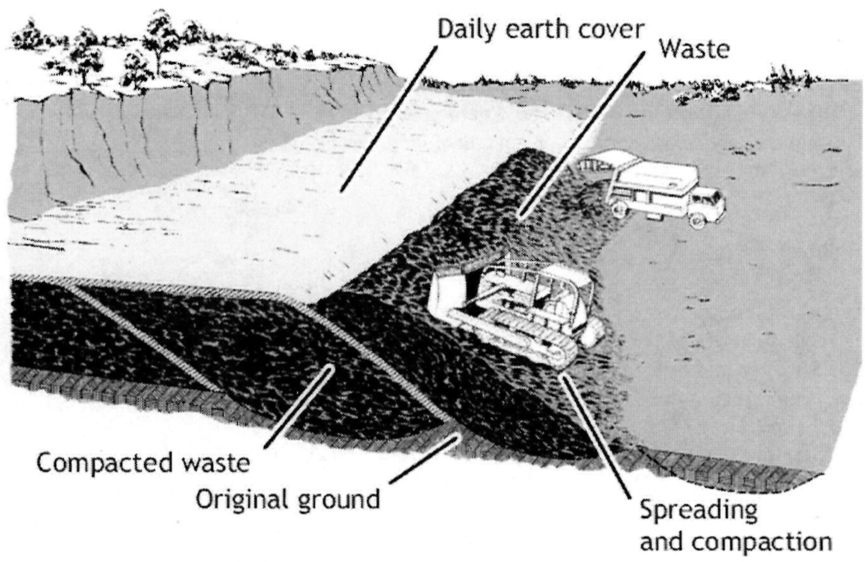
Both the NRC and the RI investigations drilled soil borings, performed downhole gamma logging of the soil borings and collected soil samples for laboratory analyses. One or two soil samples were collected from each of the RI soil borings and submitted to an offsite laboratory for radiochemical analyses. No soil boring logs were included or described in the NRC reports and there is no indication that the materials encountered during drilling of the soil borings were logged or recorded during the NRC study. Cuttings generated during drilling of the RI soil borings were logged and described by a field geologist (soil boring logs are included in the RI reports) based on inspection of large diameter bucket auger cuttings. The field geologists' observations indicate that the soil material within the landfill does not occur in a discrete layer or layers but instead is interspersed within the overall matrix of landfill wastes.

3.3.2 Consideration of Solid Waste Landfill Practices

Solid waste disposal methods do not result in a continuous and homogenous waste mass, but rather a series of smaller pockets or cells of waste next to each other, due to the progressive filling with waste over time. Each landfill cell is open and operated for a period of time (days, weeks, months or in some instances years) depending upon the size of the cell and the amount and rate of materials disposal at a site. Standard operating practice (EPA 1972), and since the 1970s and 1980s federal and state regulations, require placement of a thin layer of soil (currently 6-inches but minimum amounts were not specified prior to the 1970's and 1980s) over the waste materials at the end of each day of operations. Standard practice (EPA 1972) and later regulations required that areas in which landfill operations had been completed or that were not used for waste disposal for a period of six months or more be covered with an intermediate soil cover, generally consisting of approximately 12 inches of soil. Conceptual drawings illustrating landfill construction and operation activities that EPA presented during the public meetings for the site are presented below.

Construction of a solid waste landfill involves several processes that are specifically intended to redistribute or that indirectly redistribute the waste materials, including any soil material used for daily or intermediate cover during landfill operations. These processes include the following: initial dumping of the waste in or near a waste disposal cell; spreading of the wastes within the disposal cell; compaction of the wastes within a disposal cell; placement of daily soil cover layer over the disposal cell; dumping, spreading and compaction of wastes in the overlying disposal cells; placement of daily cover on top of the overlying disposal cells; placement and compaction of intermediate soil cover layer over completed disposal cells; and placement and compaction of final soil cover and construction of the vegetation layer. As can be seen in the figure below, daily soil cover layers are not necessarily placed in uniform, horizontal layers. In most landfills, intermediate soil cover layers also tend to be non-horizontal as compaction of landfill waste are configured for drainage or part of an exterior landfill sideslope. Proper landfill operation calls for daily and intermediate soil cover to be applied to both the top and sideslopes as construction of a landfill cell progresses, with the intent of leaving only the working face exposed. Proper landfill operation calls for covering of the working face at the end of each day of operations. Construction of landfill cells in this manner results in non-uniform, non-horizontal layers where soil used as daily or intermediate cover is present within the landfill mass.

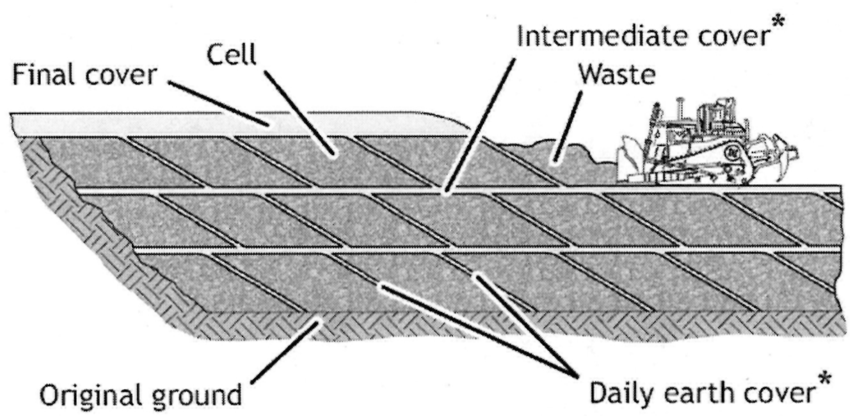
GENERALIZED LANDFILL OPERATION



Solid waste materials have different strengths and therefore do not compact equally. Large or more solid items such as construction and demolition debris, appliances, and other objects are strong and dense and subject to minimal compaction whereas household trash, yard trimmings, and other more putrescible wastes are weaker, less dense and more compressible through compaction. Consequently, solid waste materials are subject to differential compaction through the operating life of a landfill. Differential compaction and other processes result in differential displacement of the waste materials and soil cover layers immediately upon and long after placement of these materials in the landfill cell. Thus, although a daily or intermediate soil layer may be placed over a landfill cell at one time, from the time it is initially placed and subsequently through the years that follow, such soil layers do not occur or remain as a discrete, identifiable, homogeneous, isolated layers within a landfill but become mixed within the overall matrix of solid wastes disposed in the landfill.

Solid waste materials are also subject to microbial degradation, specifically anaerobic microbial degradation. It is the microbial degradation of the solid waste materials that results in generation of significant amounts of methane gas within solid waste landfills. It is well established that methane gas generation peaks within a few years after completion of landfilling and covering of a landfill and declines with time. Methane gas generation is a result of the overall microbial degradation, which consequently is also more extensive during the initial years after closure of a landfill. Microbial degradation results in decomposition of the waste materials which in turn causes compaction and settlement of the waste materials. Due to variations in the waste composition, landfill construction, variations in the waste moisture content and contact with

GENERALIZED LANDFILL CELL CONFIGURATION

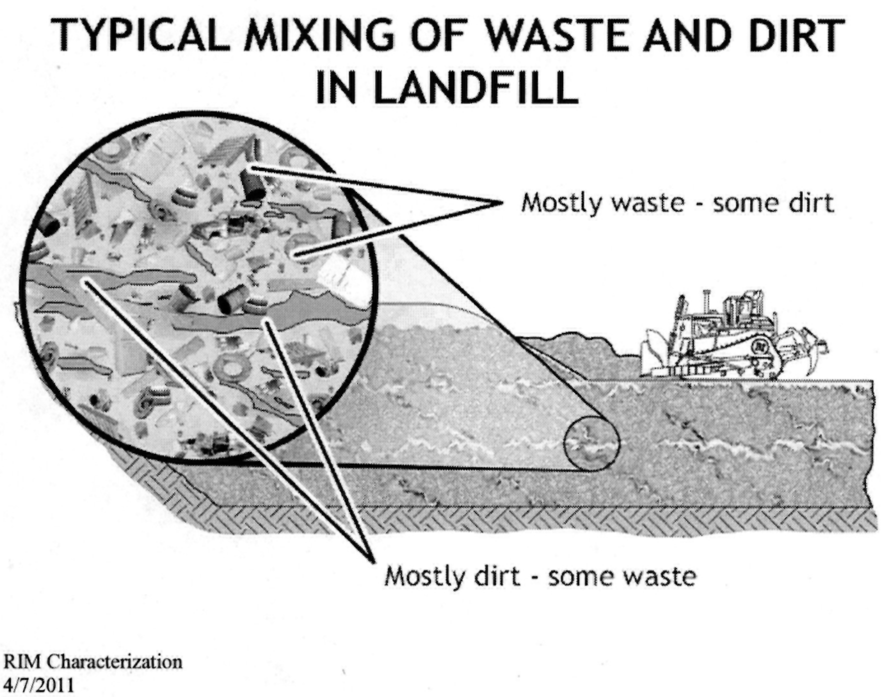


* Idealized soil layers. This configuration does not reflect mixing of soil with trash or distortion of soil layers by subsequent compaction and placement of additional fill.

precipitation, and other factors, decomposition, compaction and settlement of landfill waste materials does not occur in a uniform manner but rather landfill wastes are subject to differential compaction and settlement. Differential compaction and settlement is a condition that occurs over time and results in changes to the vertical distribution of the waste materials, and in particular the thin layers of daily and intermediate soil cover placed over the waste materials when active landfilling operations were being performed.

As a result of the processes initially conducted during construction of a landfill (i.e., waste dumping, spreading, compaction, placement of daily soil cover, construction of overlying waste cells, placement of intermediate soil cover, and construction of a final landfill cover as described above), plus the effects of microbial degradation and resultant additional differential compaction and settlement, the initially placed irregular soil cover layers become further disrupted and dislocated within the overall landfill mass.

Sanitary landfill wastes also settle as a result of filtering of fines (e.g., soil or other fine material moving downward through the landfill mass in response to gravity or water flow). The weight of the landfilled wastes also causes compaction and differential settlement of the waste materials. Application of superimposed loads resulting from stockpiling of soil or other materials over completed cells, or interim portions of a landfill, can cause significant compaction and differential settlement. This is a significant factor for a site such as the West Lake Landfill which also was used for stockpiling sand and gravel and other materials. Placement of stockpiles over previously deposited wastes results in significant additional compaction beyond that achieved with landfill equipment alone. As the placement of stockpiled materials is not uniform over a landfill surface and changes with time and continued operations, the resultant differential compaction and settlement that occurs is highly variable.



3.3.5 Summary of General Distribution of RIM

Based on the results of both the NRC and RI investigations and consideration of the nature of landfill operations and landfill wastes, it is logical to assume that the soil containing radionuclides is intermixed with and interspersed within the overall matrix of landfilled refuse, demolition and construction debris, fill materials, and unimpacted soil. In some portions of Areas 1 and 2, radiologically impacted materials are present at the surface; however, the majority of the radiological occurrences are present at depth in these two areas.

3.4 Depth of RIM Occurrences

RIM is present both at the ground surface and in the subsurface in Areas 1 and 2. Both the NRC investigations (NRC, 1982 and 1988) and the RI investigations concluded that the subsurface extent of the RIM occurrences is greater than the surface extent.

The 1988 NRC report concluded "Contaminated soil (>5 pCi Ra-226 per gram) is found from the surface to depths as great as 20 feet below the surface." The 1988 NRC report further states "In general, the contamination appears to be a continuous single layer ranging from 2 to 15 feet thick and covering 16 acres."

The RI investigation did not identify any distinct or definable soil layers, whether radiologically impacted or otherwise, within the landfill matrix.

With respect to the depth of RIM in Area 1 the RI found that radiologically impacted materials were present in the subsurface of Area 1 at two different depths. In the northwestern part of Area 1, radiologically impacted materials were identified at depths generally ranging between 0 and approximately 6 feet. In the southeastern portion of Area 1, radiologically impacted materials occur at a somewhat deeper interval ranging from 0 to approximately 15 feet. The data from the RI suggest that the depth and elevation at which the radiologically impacted materials occur varies highly over even small distances indicating that the horizon(s) in which the radiologically impacted materials occur are highly variable and highly irregular.

With respect to Area 2, the RI found that based upon the results of the downhole gamma logging and the laboratory analyses, radiologically impacted materials were generally found at depths ranging between 0 to approximately 6 feet in the northern portion of Area 2. These depths correspond to elevations of approximately 457 to 462 feet above mean sea level. Deeper occurrences of radiologically impacted materials were identified in a few borings in the northern portion of Area 2 such as at boring WL-226.. In the southern part of Area 2, radiologically impacted materials were identified at depths generally ranging between 0 and 6 feet. Deeper occurrences of radiologically impacted materials, were identified at several locations including at a depth of 27-ft in boring WL-233.

The RI borings were drilled to depths of 15 to 105 ft bgs in Area 1, and 11 to 146 ft bgs in Area 2. Gamma logging of the RI borings was performed to depths ranging from 11 to 102 ft bgs in

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Nearly fifteen years elapsed between the time the NRC field work was performed (1981) and the time the RI field investigations were conducted (1995). Not surprisingly for a landfill site containing waste materials that are subject to microbial degradation, progressive decomposition and differential compaction, and settlement occurred as described above. The NRC investigation was performed only a few years after Areas 1 and 2 had been closed and at a time when ongoing landfilling and sand and gravel extraction and stockpiling were still occurring within the 200 acre site boundaries. For example, the 1980 RMC report (RMC was the contractor that performed the work for the NRC study) states "The [site] visit had been delayed over one month due to ongoing landfill operations in the area of interest to RMC." This report further states "This estimate [of the areal extent of contamination] assumes that contamination extends under the existing stone and gravel piles, where readings could not be mad ... [1]

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the Area 1 soil borings, and 7 to 54.5 ft bgs in the Area 2 soil borings. The average depth of the twenty RI borings drilled and logged in Area 1 was 38 ft bgs while the average depth of the 34 RI borings drilled in Area 2 was 31 ft bgs. Based on both downhole gamma logging and/or analytical laboratory results, the RI identified a number of locations where contaminated materials were present at depths below 20 ft bgs, and indeed extending to depths of as much as nearly 50 ft bgs at some locations.

3.5 Radiological Characterization of the RIM

In general, the primary radionuclides detected in Areas 1 and 2 at levels above background concentrations are part of the Uranium-238 and Uranium-235 decay series. Thorium-232 and Radium-224 isotopes from the Thorium-232 decay series were also present above background levels but at a lesser frequency.

During the RI, a total of 134 soil samples, including 12 duplicate samples, were collected and submitted to an offsite laboratory for radionuclide analyses. This included 54 total samples (including 6 duplicate samples) from Area 1 and 80 total samples (including 6 duplicate samples) from Area 2. The maximum detected values for Radium-226, Thorium-230 and Uranium-238 reported for the RI samples obtained from Area 1 were 906, 9,700 and 147 pCi/g respectively. The maximum detected values for Radium-226, Thorium-230 and Uranium-238 reported for the RI samples obtained from Area 2 were 3,060 (duplicate result of 1,260), 57,300 (duplicate result of 12,000) and 294 pCi/g respectively. A complete listing of the RI analytical results is presented in the RI report.

The NRC characterization of the radionuclide activity levels was a screening level evaluation based on the results of the downhole logging and resultant calculated values for individual radionuclide activity levels. Only two subsurface soil samples (the depths of which were unspecified) were obtained by the NRC and submitted to an offsite laboratory for radiochemical analyses and neither of these samples was analyzed for Radium-226. In addition, Radium-226 activity levels from soil borings drilled in Area 1 were not measured or calculated in the NRC study.

The NRC report includes calculated radionuclide activities based on field measurements with a very limited number of laboratory analyses for a very limited number of parameters. Because the NRC investigation relied primarily on field screening methodologies, the accuracy and precision of the NRC results cannot be assessed. The RI results are based on over 100 analytical laboratory results obtained in accordance with EPA-approved analytical methods and quality control/quality assurance procedures for which the reported results include known accuracy and precision. Consequently, evaluations of the nature and extent of contamination and potential risks has been performed using only the RI analytical results.

Overall, the findings and conclusions of the remedial investigation (RI) about the location and nature of the radioactivity at West Lake Landfill are in agreement with those reported by contractors to the U.S. Nuclear Regulatory Commission in the 1980s (NRC 1988 and 1982 and RMC 1981). Both investigations identified approximately the same two areas (so-called

Deleted: Review of the NRC and RI studies identified fifteen locations where NRC and RI soil borings were drilled in the same general areas. Table 1 presents a summary comparison of the results of downhole logging and soil sample activity levels developed by the NRC and RI investigations for soil borings located in approximately the same general locations. For example, RI boring WL-112 was drilled in Area 1 approximately 80-ft to the northeast of NRC boring no. 38 (referred to in the RI as PVC-38 reflective of the existing PVC-casing installed by the NRC that was subsequently identified and located during the RI). ¶

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A total of 27 of the NRC borings were re-logged as part of the RI study. Table 2 lists and compares the results for the peak (highest) gamma readings obtained during the NRC and RI studies. For the most part the re-logging of the NRC borings during the RI yielded similar results to those observed by the NRC study; however, there were a few exceptions. The RI re-logging identified a distinct gamma peak in NRC boring 10 (PVC-10) at a depth of 10 ft bgs that was not identified by the earlier NRC logging of this boring. Similarly, the RI re-logging of NRC boring 12 (PVC-12) identified a distinct peak at a depth of 2.5 ft bgs that was not identified by the earlier NRC logging of this boring. Conversely, the NRC results indicate the presence of a slight gamma peak at a depth of 5 ft bgs but the subsequent RI re-logging did not identify the presence of elevated gamma readings at this depth interval. In addition, the depths at which some of the peak values were identified at some locations varied (between 1 to 3 ft) between the two studies (e.g., NRC borings 5, 7, 9, 25 and 33). ¶

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The results of the downhole gamma logging obtained by the NRC and RI studies from the generally but not strictly co-located soil borings were compared to assess the comparability of the data and potential variations in radionuclide activities in Areas 1 ... [8]

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Radiological Disposal Areas 1 and 2) where radiologically impacted materials (RIM) are present at the Site. Both studies found that the radioactivity at the Site results from occurrences of uranium and its decay products and is dominated by thorium-230 and radium-226. Both studies determined that the levels of radium-226 at the Site are not in radioactive equilibrium with the levels of thorium-230 and, consequently, the levels of radium-226 are anticipated to increase during the next few hundred years as a result of decay of thorium-230. Both studies determined that the then-existing and expected future concentrations of radionuclides are significantly elevated, relative to proposed cleanup levels. Both studies determined that the subsurface occurrences of RIM extend beyond the limits of the surface occurrences of RIM. Finally, both studies concluded that the majority of the RIM is located within approximately 15 feet of the ground surface.

3.6 Radionuclide Decay and Ingrowth

Radionuclides present in Area 1 and 2 are derived from Uranium-238 and Uranium-235 and its decay products. The primary decay products of concern are TThorium-230 and Radium-226 owing to the higher activity (concentration) levels, higher radiation levels, and/or longer half lives of these isotopes. Although the various studies of radionuclide occurrences at the West Lake Landfill may have characterized different suites of radionuclides, all of the studies evaluated the nature and extent of Thorium-230 and Radium-226 and all identified the presence of these isotopes as the primary radionuclides of concern at the Site.

Results of all of the investigations of the site have identified that the activity level of Thorium-230 exceeds, and is not in equilibrium with that of the other radionuclides, notably, Radium-226. Consequently, as a result of decay of Thorium-230, the levels of Radium-226 are expected to increase over time as noted in the NRC reports (NRC, 1982 and 1988). The projected increase in Radium-226 levels over time will be expected to result in both increased radiation levels and increased radon gas generation over time. The projected increase in radiation and radon levels over time were addressed as part of the risk characterization included the Baseline Risk Assessment (Auxier & Associates, 2000).

The increased radiation and radon gas emissions resulting from decay of Thorium-230 over time are also addressed in this SFS report. Specifically, the anticipated increase in radiation levels owing to increased Radium-226 levels over time was addressed by insuring that the new landfill cover was sufficiently thick so as to provide sufficient protection against the calculated levels of radiation resulting from in-growth of Radium-226 over time (1,000 years) from Thorium-230 decay. The increased levels of radon gas expected to occur as a result of in-growth of Radium-226 over time (1,000 years) from Thorium-230 decay were also addressed through use of the calculated radon emissions over time (1,000 years) to determine the thickness of the landfill cover required to attenuate radon emissions The thickness of the landfill cover for the on-site disposal cell alternative was also evaluated to address radon attenuation.

3.7 Principal Threat Waste Analysis

Deleted: Overall, the findings and conclusions of the remedial investigation (RI) about the location and nature of the radioactivity at West Lake Landfill are in agreement with those reported by contractors to the U.S. Nuclear Regulatory Commission in the 1980s (NRC 1988; RMC 1981). Both investigations identified approximately the same two areas (so-called Radiological Disposal Areas 1 and 2) where radiologically impacted materials (RIM) are present at the Site. Both studies found that the radioactivity at the Site results from occurrences of uranium and its decay products and is dominated by thorium-230 and radium-226. Both studies determined that the levels of radium-226 at the Site are not in radioactive equilibrium with the levels of thorium-230 and, consequently, the levels of radium-226 are anticipated to increase during the next few hundred years as a result of decay of thorium-230. Both studies determined that the then-existing and expected future concentrations of radionuclides are significantly elevated, relative to proposed cleanup levels. Both studies determined that the subsurface occurrences of RIM extend beyond the limits of the surface occurrences of RIM. Finally, both studies concluded that the majority of the RIM is located within approximately 15 feet of the ground surface. For example, RIM was identified during the RI in Area 1 at depths generally ranging between 0 and approximately six feet in the northwestern portion (see RI at page 92) and between 0 and approximately 15 feet in the southeastern portion (see RI, at page 92) and with an average thickness of approximately three feet (see RI, at page 93). RIM was identified during the RI in Area 2 at depths generally ranging between 0 and approximately six feet in both the northern portion (see RI at page 97) and southern portion (see RI, at page 92) and with an average thickness of approximately four feet (see RI, at page 98). Due largely to the greater depth of the RI borings, the RI did identify occurrences of RIM at depths below 15 ft in several areas in Area 2. ¶

EPA expects that treatment will be the preferred means by which to address the principal threats posed by a site, wherever practicable. Principal threat wastes are characterized as waste that cannot be reliably controlled in place, such as liquids, highly mobile materials (e.g., solvents), and high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure). (See 55 FR 8703, March 9, 1990)"

Evaluation of potential occurrences of principal threat wastes at OU-1 was performed in conjunction with the initial February 2000 draft Feasibility Study (FS) report (EMSI, 2000a) and the subsequent September 2000 evaluation of potential "hot spot" removal (EMSI, 2000b). Both of these evaluations concluded that the radiologically-impacted materials at the site were not principal threat wastes. These same evaluations were included in subsequent drafts of the FS report (EMSI, 2002, 2004, and 2005) and in the final FS report (EMSI, 2006) that was accepted by EPA and used as a basis for development of the Proposed Plan and Record of Decision.

EPA subsequently determined in the Record of Decision that no principal threat wastes are present at the site (EPA, 2008). EPA found that the hazardous substances present in OU-1, including the radionuclides, are dispersed in a heterogeneous mix of municipal solid wastes. The preamble to the NCP identifies municipal landfills as a type of site where treatment of waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in CERCLA municipal landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. EPA has established source containment as the presumptive remedy for CERCLA municipal landfill sites. The NCP also contains an expectation that treatment should be considered for identifiable areas of highly toxic and/or mobile material (hot spots) that pose potential principal threats. Such an evaluation was previously performed for OU-1 and is presented in the original Feasibility Study (FS) report.

The purpose of the SFS is to provide as thorough an evaluation as possible of the potential "complete rad removal" alternatives relative to the ROD-selected remedy. Therefore, for purposes of the SFS, it is conservatively assumed that principal threat wastes may be present within OU-1, and therefore potential treatment technologies are evaluated in Section 5 of this SFS as if principal threat wastes were present. As discussed in Section 5, the evaluation of potential treatment technologies reflects the presence of the RIM within an overall matrix of solid wastes and the expected further in-growth of radionuclides due to radioactive disequilibrium.

Deleted: This subsection presents and evaluation of potential occurrences of Principal Threat Wastes in Areas 1 and 2.

Deleted: 3.7.1 Regulatory Background¶

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The National Contingency Plan (NCP) establishes an expectation that treatment will be used to address the principal threats posed by a Site whenever practicable [section 300.430(a)(1)(iii)(A)]. EPA experience with site remediation indicates that certain source materials are best addressed through treatment because of technical limitations to the long-term reliability of containment technologies, or the serious consequences of exposure should a release occur (EPA, 1991a). ¶

¶

The concept of principal threat waste and low level threat waste as developed by EPA in the NCP is to be applied on a site-specific basis when characterizing source material (EPA, 1991a). Source material is defined as material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure (EPA, 1991a). Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or which would present a significant risk to human health or the environment should exposure occur (EPA, 1991a). They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds (EPA, 1991a). No threshold level of toxicity/risk has been established to equate to "principal threat"; however, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated (EPA, 1991a). Low level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of a release (EPA, 1991a).¶

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The identification of principal and low level threats is made on a site-specific basis. Determination as to whether a source material is a principal or low level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility ... [12]

Deleted: In appropriate circumstances, excavation and/or treatment of "hot spots" should be evaluated.

Deleted: 3.7.3 Additional SFS Evaluations of Potential Principal Threat Wastes

Deleted: The potential for occurrence of principal threat wastes (PTW) was re-evaluated in this SFS. The factors listed in EPA's 1991 guidance on PTW, as described above, were used to evaluate the potential for occurrence of PTW in OU-1 at West Lake Landfill.¶

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Liquid – OU-1 contains municipal solid wastes including household wastes, construction and demolition debris, and possibly industrial w ... [13]

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3.3.3 Time Between Studies

Nearly fifteen years elapsed between the time the NRC field work was performed (1981) and the time the RI field investigations were conducted (1995). Not surprisingly for a landfill site containing waste materials that are subject to microbial degradation, progressive decomposition and differential compaction, and settlement occurred as described above. The NRC investigation was performed only a few years after Areas 1 and 2 had been closed and at a time when ongoing landfilling and sand and gravel extraction and stockpiling were still occurring within the 200 acre site boundaries. For example, the 1980 RMC report (RMC was the contractor that performed the work for the NRC study) states "The [site] visit had been delayed over one month due to ongoing landfill operations in the area of interest to RMC." This report further states "This estimate [of the areal extent of contamination] assumes that contamination extends under the existing stone and gravel piles, where readings could not be made."

3.3.4 Degree of Specificity

There is also a question as to the degree of reliability or emphasis that should be placed on the NRC description of the nature and distribution of the RIM within Areas 1 and 2. The 1982 NRC report states "...the original volume of 40,000 tons has been diluted by a factor of about 4, which is not unexpected, with the continual movement and spreading of materials during filling operations." The NRC description of the distribution of the contaminated soil states "In general, the contamination appears to be a continuous single layer ranging from 2 to 15 feet thick and covering 16 acres." This statement begins with the qualifier "In general ..." without providing any description of the range of variability of the distribution of the waste materials or the degree of reliability subsequent readers should place on this sentence. The sentence could simply be intended to indicate that the contaminated soil is not randomly distributed within the landfill and not intended to provide a definite statement that the contaminated soil only occurs as an identifiable, homogeneous, discrete layer. Likely this sentence was intended to indicate that the occurrences of elevated gamma readings reflective of the presence of contaminated soil were identified within specific depth intervals and not to imply that the contaminated soil itself occurs in an isolated, discrete, homogeneous layer in Areas 1 and 2. This is supported by the statement presented in the 1988 NRC report "The manner of placing the 43,000 tons of contaminated soil in the landfill caused it to be mixed with additional soil and other material, so that now an appreciably larger amount is involved." The uncertain nature of the NRC's description of the occurrences of contaminated soil within Areas 1 and 2 is further reflected by the uncertainty expressed by the NRC regarding the volume of contaminated soil when the 1988 NRC report goes on to state "If it [the contaminated soil] must be moved, it is not certain whether the amount requiring disposal elsewhere is as little as 60,000 tons or even more than 150,000 tons."

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report found that states at page __ or Section __:

Review of the boring log information does not indicate the presence of

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Based upon the information presented in this section, it is EMSI's opinion that the sources of the radiological occurrences are dispersed within the volume of landfill materials described above for Areas 1 and 2.

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One location in Area 1 contains three borings (WL-105, well S-5, and well I-4) in close proximity that were all downhole logged for gamma radiation. Although the existing ground surface elevation of these three borings was quite close (467.2, 465.7, and 466 feet above mean sea level respectively) the depths to the gamma peak in each of these borings varied significantly. Depths of the gamma peaks and corresponding elevations ranged from 9-ft (elevation 458.2-ft) in WL-105 to 3.5-ft (elevation 462.2-ft) in well S-5 to 6.5-ft (elevation 459.5-ft) in well I-4. These data suggest that the depth and elevation at which the radiologically impacted materials occur varies highly over even small distances indicating that the horizon(s) in which the radiologically impacted materials occur are highly variable and highly irregular.

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The sample obtained from the 20-foot depth in boring WL-226 contained 173-pCi/g Thorium-230 along with other radionuclides above background levels. This boring also displayed a downhole gamma peak at the 11-foot depth. Borings PVC-5, PVC-6, and PVC-7 displayed two separate gamma peaks with the lower peaks occurring at depths of 11 to 19.5 feet. Elevated downhole gamma readings were detected at a depth of 8-feet in boring PVC-19. A second interval of elevated downhole gamma readings was measured at a depth of 7-feet in boring PVC-40. The sample from the 25-foot depth in WL-209 displayed a Thorium-230 concentration (26.9 pCi/g) greater than the subsurface reference level (17.45 pCi/g); however, analysis of the field duplicate sample from this same location and depth did not contain Thorium-230 above the subsurface reference level (12.85 pCi/g).

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in the southernmost portion of Area 2 where Thorium-230 was detected at the 27-foot depth at 427 pCi/g. Elevated downhole gamma readings were identified at a depth of 22 feet in this boring. Several radionuclides of the Uranium-238 decay series were detected at concentrations greater than their reference levels in the sample from the 10-foot depth from boring WL-234. A second interval of elevated gamma readings was identified at the 10-foot depth in boring PVC-10

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Both the NRC and the RI investigations drilled soil borings, performed downhole gamma logging of the soil borings and collected soil samples for laboratory analyses to define the lateral and vertical extent of radionuclide occurrences in Areas 1 and 2. As discussed above, no soil boring logs were included or described in the NRC reports while generalized boring logs based on inspection of large diameter bucket auger cuttings were included in the RI. Downhole gamma logs are included in the RI but are not included in the NRC reports; however, the NRC reports do contain tabular summaries of the downhole gamma counts for each 1-ft depth interval logged.

One or two soil samples were collected from each of the RI soil borings and submitted to an offsite laboratory for radiochemical analyses. The NRC studies utilized an in situ gamma measurement system consisting of an intrinsic germanium (IG) detector coupled to a multichannel analyzer to perform qualitative and quantitative field analyzes during logging of the boreholes. Only eight surface soil samples (the locations of which are unspecified for most of the samples) and two borehole samples (sample depths unspecified) were collected and submitted for offsite radiochemical analyses as part of the NRC studies.

In addition to the differences in the general characterization of the depth of RIM between the RI and the NRC reports, the reported depths of the subsurface RIM occurrences differed between the two reports. As stated above, the 1988 NRC report states that "Contaminated soil (>5 pCi Ra-226 per gram) is found from the surface to depths as great as 20 feet below the surface." Although generally correct, the NRC characterization of the depth of contamination is not strictly correct in all cases. NRC logging of boring no. 22 indicated elevated gamma readings (>50,000 cpm) and corresponding elevated Radium-226 values (calculated values of 640 to 5,800 pCi./g) at depths of 23 to 25 ft bgs in this boring. The 25 ft depth was the maximum depth drilled so the actual vertical extent of contamination at this location cannot be determined from the available information. This boring was located in the southern portion of Area 2; however, this boring was not located during the RI field work. RI soil borings WL-233 and WL-235 were drilled near the presumed area of NRC boring no. 22. Logging of WL-233 and WL-235 identified the presence of elevated gamma readings with peak levels occurring at 22 and 22.5 ft bgs respectively. The NRC borings were drilled and logged to depths ranging from 21 to 39 ft bgs in Area 1, and 9 to 36 ft bgs in Area 2. The average depth of the ten NRC borings drilled and logged in Area 1 was 26.3 ft bgs while the average depth of the 30 NRC borings drilled and logged in Area 2 was 22.3 ft bgs. Nearly one fourth of the NRC borings (nine of the 39 borings drilled in areas 1 and 2) were drilled to depths of less than 20 ft bgs. All of these shallower borings were located in Area 2 where the RI identified the presence of deeper occurrences of RIM.

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Review of the NRC and RI studies identified fifteen locations where NRC and RI soil borings were drilled in the same general areas. Table 1 presents a summary comparison of the results of downhole logging and soil sample activity levels developed by the NRC and RI investigations for soil borings located in approximately the same general locations. For example, RI boring WL-112 was drilled in Area 1 approximately 80-ft to the northeast of NRC boring no. 38 (referred to in the RI as PVC-38 reflective of the existing PVC-casing installed by the NRC that was subsequently identified and located during the RI).

A total of 27 of the NRC borings were re-logged as part of the RI study. Table 2 lists and compares the results for the peak (highest) gamma readings obtained during the NRC and RI studies. For the most part the re-logging of the NRC borings during the RI yielded similar results to those observed by the NRC study; however, there were a few exceptions. The RI re-logging identified a distinct gamma peak in NRC boring 10 (PVC-10) at a depth of 10 ft bgs that was not identified by the earlier NRC logging of this boring. Similarly, the RI re-logging of NRC boring 12 (PVC-12) identified a distinct peak at a depth of 2.5 ft bgs that was not identified by the earlier NRC logging of this boring. Conversely, the NRC results indicate the presence of a slight gamma peak at a depth of 5 ft bgs but the subsequent RI re-logging did not identify the presence of elevated gamma readings at this depth interval. In addition, the depths at which some of the peak values were identified at some locations varied (between 1 to 3 ft) between the two studies (e.g., NRC borings 5, 7, 9, 25 and 33).

The results of the downhole gamma logging obtained by the NRC and RI studies from the generally but not strictly co-located soil borings were compared to assess the comparability of the data and potential variations in radionuclide activities in Areas 1 and 2. For example, downhole logging performed during the RI identified a peak gamma reading of 10,000 counts per minute (cpm) at a depth of 6.5 ft below ground surface (bgs) in WL-112. Downhole logging performed by NRC in NRC boring no. 38 identified a peak gamma reading of 5,000 cpm at a depth of 7 ft bgs. Re-logging of NRC boring no. 38 was performed through the PVC casing during the RI. This re-logging identified a peak gamma reading of 17,000 cpm at a depth of 8 ft bgs. All of the results of the gamma logging indicate the presence of radionuclides within the waste materials at a depth of approximately 6.5 to 8 ft bgs in the area of RI boring WL-112 and NRC boring no. 38. Similarly, RI boring WL-209 was drilled approximately 25 ft to the south of NRC boring no. 4 and approximately 60 ft to the west of NRC boring no. 7. Downhole logging of RI boring WL-209 identified a peak gamma reading of 744,000 cpm at a depth of 0.5 ft. NRC logs for borings 4 and 7 identified gamma peaks of greater than 50,000 cpm at depths of 0 – 2 ft bgs in both borings. Relogging of these same two borings during the RI identified a gamma peak of 1,290,000 cpm at a depth of 1 ft bgs in boring 4 and 1,386,000 cpm at a depth of 3 ft in boring 7.

Review of the data presented on Table 2 indicates that a high degree of variability exists in the locations and intensity of the radionuclide occurrences in Areas 1 and 2. Both the NRC and the RI investigations identified the presence of elevated gamma readings in many of the proximal boring locations, at similar depth intervals with similar activity levels (e.g., WL-112/PVC-38, WL-114/PVC-26, WL-117/PVC-36, WL-209/PVC-4, WL-209/PVC-7, and WL-226/PVC-19) and in one instance (WL-222/PVC-34) both studies identified the absence of elevated gamma levels in the same general area. In other instances, elevated gamma levels were not found to be present in an RI boring drilled near an NRC boring that identified the presence of a gamma peak (e.g., WL-115/PVC-25, WL-118/PVC-26, and WL-227/PVC-40) or elevated gamma readings were identified in an RI boring in one area (WL-113/PVC-27) where elevated gamma readings were not found by the NRC study.

The causes of the differences in the description of the depth of contamination between the NRC and RI reports include:

Differences between the locations of many of the RI soil borings compared to the NRC soil borings;

Differences in the depth of the soil borings and/or the depth of gamma logging between the RI and NRC studies; and

As discussed further below, the general lack of laboratory analytical data from the NRC study, in particular almost no data (field or laboratory) for Th-230 (8 surface soil samples the locations for most of which are unspecified and two subsurface samples the depths of which are unspecified in the NRC study), compared to the extensive soil sample analytical results (over 120 sample were subjected to laboratory analyses, not counting background, duplicate, or Ford property samples, including 48 samples from Area 1 and 74 samples from Area 2) obtained as part of the RI.

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The highest Radium-226 activity value reported in of the NRC report was 440,000,000 (4.4 x 10^9) pCi/g for a sample obtained from the 18 ft depth from NRC boring No. 21 located in the southern portion of Area 2. This value appears to be incorrect and is not considered to be reliable as it is never discussed in the text of the NRC report and is inconsistent with the downhole gamma logging results obtained from this boring and depth interval. It would appear that this value may have been a typographical error. Based on the downhole gamma results and the results for the other radionuclides reported for this same depth interval, it appears that the Radium-226 activity likely was 4.4 pCi/g (4.4 x 10^0). The next highest Radium-226 value presented in the NRC report is 22,000 pCi/g obtained from the 2-ft depth interval in NRC boring No. 1; however, the location of this boring is not provided on any of the figures in the 1982 or 1988 NRC reports. Given the lack of documentation regarding the values and locations of the two highest Radium-226 results reported in the NRC study, the validity of these results is questionable.

The third, fourth, and fifth highest Radium-226 values reported in the NRC report are 15,000 pCi/g for the 1 ft depth sample in boring No. 3, 13,000 for the 2 ft depth interval in boring No. 11, and 11,000 pCi/g for the 15 ft depth sample in boring No. 16. These borings were located in the central and southern portions of Area 2. By comparison, the maximum reported Radium-226 activity level reported by the analytical laboratory in <u>any</u> of the 134 RI soil samples was 3,060 pCi/g found in the 10-ft depth sample obtained from boring WL-234 located in southern portion of Area 2. Accordingly, the RI-documented values for Radium-226 are an order of magnitude lower than the NRC reported values.

The highest Uranium-238 value listed in the NRC report is 2,900 pCi/g for the 2-ft depth in boring No. 11. In contrast, the maximum reported Uranium-238 activity level reported by the analytical laboratory in <u>any</u> of the 134 RI soil samples was 294 pCi/g found in the surface sample obtained from boring WL-209 located in north-central portion of Area 2. Similar to the Radium levels, the RI-documented values for Uranium-238 are an order of magnitude lower than the NRC report values.

In summary, t

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Furthermore, with respect to some of the highest radionuclide results reported by the NRC, the available documentation is incomplete or the reported results are inconsistent with other data obtained by the NRC. In contrast,

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The RI results do not support the Radium-226 and Uranium-238 activity levels presented in the NRC report. Given the questionable reliability of the NRC results compared to the more documented reliability of the RI results

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3.7.1 Regulatory Background

The National Contingency Plan (NCP) establishes an expectation that treatment will be used to address the principal threats posed by a Site whenever practicable [section 300.430(a)(1)(iii)(A)]. EPA experience with site remediation indicates that certain source materials are best addressed through treatment because of technical limitations to the long-term reliability of containment technologies, or the serious consequences of exposure should a release occur (EPA, 1991a).

The concept of principal threat waste and low level threat waste as developed by EPA in the NCP is to be applied on a site-specific basis when characterizing source material (EPA, 1991a). Source material is defined as material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure (EPA, 1991a). Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or which would present a significant risk to human health or the environment should exposure occur (EPA, 1991a). They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds (EPA, 1991a). No threshold level of toxicity/risk has been established to equate to "principal threat"; however, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated (EPA, 1991a). Low level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of a release (EPA, 1991a).

The identification of principal and low level threats is made on a site-specific basis. Determination as to whether a source material is a principal or low level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the waste in the particular environmental setting, and the stability and degradation products of the material. Wastes that generally will be considered to constitute principal threat wastes include, but are not limited to:

> Liquids – waste contained in drums, lagoons or tanks, free product (NAPLs) floating on or under groundwater (generally excluding ground water) containing contaminants of concern.
>
> Mobile source material – surface soil or subsurface soil containing high concentrations of contaminants of concern that are (or potentially are) mobile due to wind entrainment, volatilizations (e.g., VOCs), surface runoff, or sub-surface transport.

Highly toxic source material – buried drummed non-liquid wastes, buried tanks containing non-liquid wastes, or soil containing significant concentrations of highly toxic materials.

Wastes that generally will be considered to constitute low level threat wastes include, but are not limited to

Non-mobile contaminated source material of low to moderate toxicity – surface soil containing contaminants of concern that generally are relatively immobile in air or ground water (i.e., non-liquid, low volatility, low leachability contaminants such as high molecular weight compounds) in specific environmental settings.

Low toxicity source material – soil and subsurface soil concentrations not greatly above reference dose levels or that present an excess cancer risk near the acceptable risk range.

In some situations, site wastes will not be readily classifiable as either principal or low level threat waste, and thus no general expectations on how best to manage these source materials of moderate toxicity and mobility will necessarily apply (EPA, 1991a). In these situations wastes do not have to be characterized as either one or the other. The principal threat/low level threat waste concept and the NCP expectations were established to help streamline and focus the remedy selection process and not as a mandatory waste classification requirement (EPA, 1991a).

3.7.2 Prior Site Determinations Regarding Principal Threat Wastes

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The potential for occurrence of principal threat wastes (PTW) was re-evaluated in this SFS. The factors listed in EPA's 1991 guidance on PTW, as described above, were used to evaluate the potential for occurrence of PTW in OU-1 at West Lake Landfill.

Liquid – OU-1 contains municipal solid wastes including household wastes, construction and demolition debris, and possibly industrial wastes. Reportedly, 8,700 tons of leached barium sulfate residue were mixed with 39,000 tons of soil and transported to the site for use as daily and intermediate cover in the solid waste landfill operation. This material was a solid and there is no information indicating or suggesting that any radiological material was disposed in liquid form, was containerized, or otherwise may occur as a liquid waste.

Mobility of Source Material – The groundwater monitoring data show no evidence of significant leaching and migration of radionuclides from Areas 1 and 2. The vast majority of the groundwater monitoring results are consistent with background concentrations. Only two wells exhibited a total Radium concentration slightly above the EPA drinking water maximum contaminant level (MCL) of 5 pCi/l with values ranging from 5.74 to 6.33 pCi/l. These occurrences are spatially isolated and not indicative of the presence of a plume or definable area of groundwater contamination. Perched water samples obtained from within the landfilled waste were sampled and analyzed and were not found to contain elevated concentrations of radionuclides. This is the case even though the waste materials have been in place with nearly flat surface grades and without a landfill cover for over 30 years. In other words, significant leaching and migration of radionuclides to perched water or groundwater have not occurred despite the fact that the landfill wastes have been exposed to worst-case leaching conditions (i.e., maximum precipitation and surface water infiltration due to nearly flat surface grades and absence of a landfill cover) over a period of decades.

The potential for future leaching to groundwater was also evaluated during the Remedial Investigation (RI) (EMSI, 2000c). A dominant factor influencing the transport and environmental fate of contaminants is the sorption-desorption process. Desorption or leaching is the process whereby molecules attached to the solid phase (in this case soil) are mobilized into the dissolved phase in water. Sorption is the process by which the molecules become or remain attached to the solid phase (soil). The degree to which a molecule is sorbed onto the soil or is leached into water is characterized by the distribution coefficient, a factor that relates the concentration sorbed onto a solid with the concentration in water in contact with that solid. The distribution coefficient values for radionuclides are relatively high, consistent with the tendency of radionuclides to remain in the soil or sediment phases rather than leaching into the water phase. Partitioning calculations using site data were presented in the RI. The calculated radionuclide concentrations based on the distribution coefficient are consistent with the groundwater sampling data collected during the RI. These calculations, along with the results of the groundwater monitoring results, support the conclusion that even in the absence of an infiltration barrier (e.g, landfill cover), impacts to groundwater over time are likely to be low.

Radionuclides generally have relatively low solubility in water and instead display an affinity to adsorb onto the soil matrix. Uranium does possess a greater solubility than that of the other radionuclides. Uranium has been detected in groundwater samples obtained from Site monitoring wells at levels of approximately 5 pCi/l or less. Uranium has been detected in upgradient, background wells at levels up to approximately 2 pCi/l. EPA has established an MCL of 30 ug/l (approximately 30 pCi/l) for Uranium in public drinking water supplies. The Uranium in the barium sulfate residue is insoluble in water; that is, the Uranium cannot be leached from the barium sulfate using water alone. Consequently, significant levels of Uranium are not expected to occur and have not been found in groundwater at the site.

Radionuclides can be transported to the atmosphere either as a gas in the case of radon or as fugitive dust in the case of other radionuclides. Both potential pathways were evaluated in the RI/FS based on site-specific data. Radon flux measurements were made at 54 locations in Areas 1 and 2. Although several locations reported high radon flux measurements, the average radon flux across Areas 1 and 2 was relatively low. The average radon flux from Areas 1 and 2 under current conditions with no landfill cap in place is less than the standard (20 pCi/m^2s) that is considered safe for tailings piles at Uranium mill tailings sites (40 CFR 192.02(b)). Release of radon is likely an exposure concern only in the hypothetical event someone occupied a building or structure on or immediately adjacent to Areas 1 and 2. Existing land-use covenants prohibit construction of buildings on Areas 1 and 2. The potential for radon emissions is easily mitigated with containment via a landfill cover.

During the RI fugitive dust monitoring was performed at locations that contain the highest radionuclide concentrations in surface soil samples. Analysis of these samples indicated that fugitive dust is not a significant pathway for radionuclide migration from Areas 1 and 2. Fugitive dust is not considered a significant pathway for radionuclide migration under current conditions, primarily because the surfaces of Areas 1 and 2 are, for the most part, vegetated. The potential for fugitive dust migration is easily mitigated with containment via a landfill cover.

Toxicity of the Source Material - There is no evidence of buried drums of non-liquid wastes or buried tanks containing non-liquid wastes in the waste materials in West Lake Landfill Areas 1 and 2. However, the radiologically contaminated soils mixed with the solid waste contain significant concentrations of naturally occurring radionuclides from the Uranium (U-238), Thorium (Th-232) and actinium (U-235) decay series.

As part of the RI, extensive surface and subsurface investigations were performed. Investigations included overland gamma surveys and an extensive soil boring and soil sampling and analysis program to characterize the distribution and extent of radiological and non-radiological constituents. Twenty borings were completed in Area 1 and forty borings were completed in Area 2. Isotopic analysis was performed on soil samples that were collected at various depth intervals that generally correlated with elevated gamma readings as measured in downhole radiological surveys. Soil analytical results were compared to reference levels derived from the soil cleanup standards in 40 CFR 192 (5 pCi/g surface and 15 pCi/g subsurface for Radium-226 or Radium-228). Maximum concentrations of some radionuclides were found to be high relative to the reference levels used in the RI (e.g., Thorium-230 greater than 10,000 pCi/g, Radium-226 greater than 1,000 pCi/g and Uranium-238 greater than 200 pCi/g). The investigations also determined that the distribution of radionuclide occurrences is quite variable and the numbers of detections in this range are small. The soil sample analytical results indicate that the average concentrations of radionuclides greater than 5 pCi/g plus background (e.g., 94 pCi/g for Thorium-230, 33 pCi/g for Radium-226 and 16 pCi/g for Uranium-238) in Areas 1 and 2 are generally more in range with reference levels.

A prior investigation conducted by the Nuclear Regulatory Commission (NRC) drilled and logged 39 soil borings including 10 borings in Area 1 and 29 borings in Area 2 (NRC, 1982). Based on its investigations, the NRC reported the presence of Radium-226 levels of up to 22,000 pCi/g (NRC, 1982 and 1988). As discussed in Sections 3.4 and 3.5, above, the location of the NRC soil boring (boring no. 1) from which the 22,000 pCi/g value was reportedly found could not be determined from the information provided in the NRC reports. Furthermore, the NRC studies did not perform radiochemical analyses of soil samples to determine the levels of Radium-226 or other radionuclides present in Areas 1 and 2. The NRC study logged representative boreholes using an in situ gamma measurement system consisting of an intrinsic germanium (IG) detector coupled to a multichannel analyzer to perform quantitative and qualitative field analyses. Finally, review of the NRC report indicates that problems were encountered in the use of this system. Specifically, the 1982 NRC report states "The field use of this system was somewhat limited by initial failure due to high humidity effects on the pre-amp components and thermal insulation of the detector housing. These problems were partially corrected by sealing the detector in an outer container and allowing dry air to flow through the container." Data generated by such field analyses may be inaccurate given that the report notes the problems were only "partially corrected", and are not of the same quality as data generated by radiochemical analyses at an offsite, EPA-certified analytical laboratory. Results of the RI sampling and offsite laboratory analyses of soil samples failed to re-produce the Radium-226 levels reported in the NRC report. A total of 48 and 73 soil samples were obtained from Area 1 and 2, respectively as part of the RI investigations (not counting field or laboratory duplicate samples or background samples). The highest Radium-226 level found in all of the RI soil samples was 3,720 pCi/g. The next highest samples contained Radium-226 levels of 3,060 pCi/g (duplicate sample reportedly contained 1,260 pCi/g), 2,970 pCi/g (duplicate sample reportedly contained 3,140 pCi/g), and 2,280 pCi/g. The vast majority of the samples contained Radium-226 levels in the range of less than 1 pCi/g to less than 20 pCi/g. Given the noted problems with the field measurement during the NRC study, it is inappropriate to draw conclusions regarding the toxicity of the source material using the results of unconfirmed field analyses reported in the NRC study.

It is also important to factor in risk analysis since the health threats posed by these radionuclides are a function not only of the concentration of the radionuclides but also the manner and time period during which someone might become exposed. The radionuclides came from processed ore residues, and the ratio of Th-230 to Ra-226 is much greater than would be the case if these radionuclides were in equilibrium. Therefore, the calculations of potential risk presented in the baseline risk assessment were adjusted for ingrowth of Ra-226 and its eight daughters from decay of Th-230 over a 1,000 year period.

The Baseline Risk Assessment (BRA) (Auxier & Associates, 2000) looked at potential exposure scenarios based on reasonably anticipated land use including groundskeepers and other workers using Areas 1 and 2 for storage or other ancillary purposes. Under the assumption that radionuclides remain at or near the ground surface, some exposure to these workers would occur. The assessment used standard exposure factors and toxicity values to estimate the health risks to these hypothetical workers. Exposure frequencies and routes of exposure vary depending on the nature of the job. Exposure duration, or the time a worker remains in the job, was assumed to be 6.6 years.

Consistent with EPA risk assessment guidance (EPA, 1989), the assessment of radiological health risks was limited to carcinogenic effects. Carcinogenicity is assumed to be the limiting deleterious effect from low radiation doses. The calculated risks are expressed in terms of increased lifetime cancer risk to the exposed individual. Under most scenarios, the calculated cancer risks are within EPA's acceptable risk range defined as 1×10^{-4} or 1 in 10,000. However, under two future receptor scenarios, the grounds keeper and the storage yard worker, the individual lifetime cancer risk was calculated to be 2×10^{-4} and 4×10^{-4} respectively, slightly exceeding the acceptable risk range. These calculated risks were based on calculated future (1,000 year) Radium concentrations of 3,224 and 3,653 pCi/g for Areas 1 and 2 respectively. The calculated risks do not meet the 10^{-3} risk level criteria set forth in EPA's 1991 guidance for identification of principal threat wastes.

Can the waste material be reliably contained - At the West Lake Landfill Site OU-1, the municipal wastes were placed above grade. The surface elevation of the site at OU-1 is 20 to 30 feet or more above the level of the historic flood plain. Most of the radiologically contaminated materials occur in the upper half of the waste fill. There is no means for water to contact the radiologically contaminated materials except through surface infiltration.

Capping through the use of engineered covers is a well understood and routinely applied technology that forms a barrier between the contaminated material and the surface. Multi-layer, natural material cover systems are effectively used to mitigate the release of radon gas, minimize water infiltration, and remain effective for long periods of time (EPA 2007).

The engineered landfill cover included in the ROD-selected remedy will be designed to prevent surface water from contacting and potentially leaching the waste material. Surface grading and run-on/run-off controls would be used to shed surface water and divert it from the disposal areas. A low permeability layer would also be incorporated to further mitigate the potential for surface water infiltration. Installation of the cover system would reduce or eliminate any perched water that currently exists within the landfill.

When caps are used to contain Radium contaminated materials they are typically designed to confine gaseous radon until it has essentially decayed. Such systems are used to contain long-lived radionuclides at large Uranium mill tailing sites where radon generation is a much greater concern than at the West Lake Site due to the vast amounts of tailings involved. Because radon decays rather rapidly (Ra-222 has a half life of 3.8 days), vertically migrating gas only needs to be detained for a relatively short period of time for the radon to decay. The engineered landfill cover included in the ROD-selected remedy will be designed and constructed with sufficient thickness of natural materials to attenuate radon. Under the selected remedy, radon measurements at the surface of the cap should be indistinguishable from background.

<u>Conclusion</u> - The radiological source material in West Lake Landfill OU-1 is not liquid; it is relatively immobile in this environmental setting; it is of low to moderate toxicity; and it can be reliably contained. Based on the considerations provided in the EPA guidance (EPA, 1991), the radiological source materials at the site are more similar to low level threat wastes than to principal threat wastes.

<u>Treatment</u> - Consistent with the NCP, EPA's expectation is that source containment technologies generally would be appropriate for municipal landfill waste because the volume and heterogeneity of the waste material generally make treatment impracticable.
This expectation is also established by the EPA directive "Presumptive Remedy for CERCLA Municipal Landfill Sites" (EPA, 1993), and EPA's "Guidance for Performance of RI/FS at CERCLA Municipal Landfill Sites" (EPA, 1991b).

In a subsequent directive "Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills" (EPA, 1996), EPA provided guidance on the application of the presumptive approach to military landfills. Generally, the presumptive approach is appropriate for military landfills that are similar to municipal landfills but may also have low-hazard military specific waste, such as low-level radioactive wastes, which are generally no more hazardous than some of the industrial or hazardous wastes frequently found in CERCLA municipal landfills. In many cases, these hazardous chemical substances (e.g., industrial wastes containing chlorinated solvents) are much more toxic and more mobile in the environment than the radionuclides found in Areas 1 and 2.

Consistent with the expectations in the NCP and related guidance for landfills, treatment to reduce toxicity, mobility, or volume is not considered practicable for the West Lake RIM. Most contaminants within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall matrix of municipal refuse and construction and demolition debris. The large scale and heterogeneous nature of the waste materials make excavation of the radiologically impacted materials for possible *ex-situ* treatment techniques impracticable. In addition, there are no *in-situ* treatment technologies that can be applied to this circumstance. Hot spots - According to the presumptive remedy guidance for CERCLA Municipal Landfills (EPA, 1993), the decision to characterize and/or treat hot spots is a site-specific judgment that should be based on a standard set of considerations. These considerations are highlighted below. As specified in the presumptive remedy guidance document, the overriding question is whether the combination of characteristics is such that leaving the waste in place would threaten the reliability of the containment system.

If all of the following questions can be answered in the affirmative, it is likely that characterization and/or treatment of hot spots is warranted:

> Does evidence exist to indicate the presence and approximate location of waste?
>
> Is the hot spot known to be principal threat waste?
>
> Is the waste in a discrete accessible part of the landfill?
>
> Is the hot spot known to be large enough that its remediation will reduce the overall threat posed by the site but small enough that it is reasonable to consider removal (e.g., 100,000 cubic yards or less)?

Based on extensive field investigation and evaluation, the nature and location of the radiological source material at OU-1 is well known. However, the answer to all other questions is negative. As discussed above, for the various criteria used to evaluate the potential for a principal threat waste, the radiological source material would be characterized as low level threat waste rather than principal threat waste. Accordingly, containment is a reliable and appropriate technical approach. Moreover, the radionuclides are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse and construction and demolition debris. Analysis of the RI boring data indicates that the vertical distribution of the radionuclides is highly variable and irregular, even over short horizontal distances. This type of distribution is not consistent with the condition that the waste be present in a discrete and accessible location. The volume of material that would need to be removed depends on whether sorting of the waste material is considered practical or economical. In any event, the volume of material that would need to be removed to recover a majority of the radiological contamination is several times larger than 100,000 cubic yards. As such, there are no hot spots in Areas 1 and 2 requiring characterization and treatment.

EPA expects that treatment will be the preferred means by which to address the principal threats posed by a site, wherever practicable. Principal threat wastes are characterized as waste that cannot be reliably controlled in place, such as liquids, highly mobile materials (e.g., solvents), and high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure). (See 55 FR 8703, March 9, 1990)"